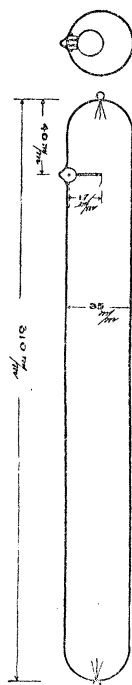


FIG. 14.



The phenomena of a plain tube are shown when the disk is down, and when up the regular bright bands are produced. This experiment is very striking.

IV. "On an Instrument for Indicating and Measuring Difference of Phase between E.M.F. and Current in any Alternating Current System." By Major P. CARDEW, R.E. Communicated by Lord KELVIN, P.R.S. Received June 21, 1894.

If the periodic time of an alternating E.M.F. be T , and if, owing to the presence of capacity or self-induction, or both in the circuit, the current passes through the value O at times differing from the times of passage of the E.M.F. through the same value by t , the electrical power will be $V \times C \times \cos (2\pi t/T)$, where V indicates the effective volts and C the effective current.

If a momentary contact be made at intervals exactly synchronising with the period of the alternating E.M.F. to complete the circuit of a suitable and suitably connected galvanometer, and if the time of

occurrence of this contact can be adjusted to any instant of the period T , the instant of passage of the alternating E.M.F. or current through O from positive to negative, or *vice versâ*, can be accurately determined.

The contact need not be absolutely momentary if the needle of the galvanometer have inertia sufficient, nor need it occur in each period, provided that the recurring period be an exact multiple of the alternating period.

On the principles enunciated above, the following simple apparatus has been devised for the exact measurement of the angle $2\pi t/T$:—

A cylinder of boxwood or ebonite is caused to rotate synchronously with the alternating current generator, making one revolution to a complete period, either by direct connexion of its axle with that of the machine through suitable multiplying gear, in a manner similar to that used for the ordinary velocimeter, or by driving it by a synchronising motor.

In the surface of the cylinder is embedded one metal wire or strip parallel with the axle, and connected to the axle or to a contact ring.

Two insulated springs press against the surface of the cylinder; one of these, called the Volt brush V , is attached to a dial face accurately marked with degrees, centred at the axis of revolution, and capable of rotation round this axis, and provided with clamping and slow motion screws; the other brush, called the current brush C , is attached to an index moving over the face of the dial, and also provided with clamping and slow motion screws. For very exact measurement the index may carry a vernier.

The brushes are so arranged that they make simultaneous contact with the wire on the cylinder when the index is exactly at the zero of the dial, and the cylinder is rotated. This is tested by means of a battery and galvanometer, and the brushes are provided with suitable means of adjustment. If the wire is of appreciable width, the adjustment of the brushes should be such as to give maximum deflection on the galvanometer.

The connexions are as follows :—One terminal of the alternator is connected to the axle or contact ring of the cylinder by means of an ordinary rubbing contact; Brush V is connected to a sensitive dead-beat galvanometer, which can be shunted at will, and coils of sufficient impedance to enable the shunted galvanometer to withstand the full E.M.F., and to the other terminal of the alternator; Brush C is connected through a resistance which can be cut out of circuit to a low resistance galvanometer, and thence to a point on the main connected with the axle of the cylinder at a short distance from this connexion, so that a short piece of main is a shunt to this galvanometer and contact.

The *modus operandi* is first to adjust the dial and Brush V until Galvanometer V remains at zero, then adjust the index and Brush C until Galvanometer C remains at zero. The angle indicated is then exactly $2\pi t/T$, measuring the difference of phase between E.M.F. and current.

It will be seen that as this is a null method, the self-induction of the galvanometer circuits does not affect the results.

V. "On the difference of Potential that may be established at the Surface of the Ground immediately above and at various distances from a buried mass of Metal charge from a High Pressure Electric Light Supply." By Major CARDEW, R.E., and Major BAGNOLD, R.E. Communicated by LORD KELVIN, P.R.S. Received June 21, 1894.

On the 8th January, 1894, an accident occurred at Bournemouth of an unusual nature. An omnibus was in the act of drawing up in the roadway outside the Imperial Hotel, when the horses suddenly fell down, and one of them died in a few minutes.

All the men who assisted in extricating the horses felt tingling sensations in their limbs suggestive of electrical shock, and the connexion from the mains of the Bournemouth Electric Light Company to the hotel was known to pass underneath the spot at which the accident occurred.

This Company use the high pressure alternating system at 2,000 volts pressure, and in the case of this hotel the transformers were installed upon the premises.

On investigation, a defect in the insulation of one of the high pressure service lines was discovered, from which sparking had evidently taken place to the enclosing $1\frac{1}{2}$ -in. wrought iron pipe.

This pipe was 32 ft. long, laid at a depth of about 18 in., and terminated at a brick junction box under the roadway, and a brick and cement area wall at the hotel. The ends were thus fairly insulated, while the rest of the pipe was in contact with the earth.

The accident took place during the progress of a thaw, after a very severe frost.

Upon consideration of the case, Major Cardew reported to the Board of Trade that in his opinion the accident was caused by leakage from the short length of charged pipe, affecting the potential of the surface of the ground to such an extent that between the fore and hind feet of the horse a sufficient difference of potential was established to give rise to the current which proved fatal.

At the same time, as the fact of such a result following from a simple contact with ordinary road material was a new experience of